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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 : G02B 6/34	A1	(11) International Publication Number: WO 89/ 02610
		(43) International Publication Date: 23 March 1989 (23.03.89)

(21) International Application Number: PCT/GB88/00741

(22) International Filing Date: 12 September 1988 (12.09.88)

(31) Priority Application Number: 8721604

(32) Priority Date: 14 September 1987 (14.09.87)

(33) Priority Country: GB

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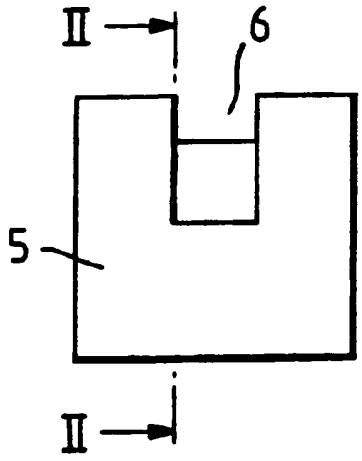
(81) Designated States: JP, US.

Published
With international search report.

(54) Title: OPTICAL FILTER



(57) Abstract

In a method of manufacturing an optical filter a monomode optical fibre (4) is mounted in a channel (6) of a silica block (5). The upper surface (10) is lapped and polished to expose a portion of the fibre core (2) to provide a polished half coupler (PHC). A thin film (7) of index matched UV curable adhesive is applied to the PHC and an ultrasonic source (8) is used to set up a standing wave in the film (7) which is then rapidly cured using a high intensity UV source (9).

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OPTICAL FILTER

The present invention relates to an optical filter and more particularly to a method of manufacturing such a filter.

It is known to provide an optical filter by overlaying a periodic structure onto a polished half coupler. In one such filter of the kind comprising an optical waveguide having a distributed Bragg Reflector, light of a wavelength which satisfies the Bragg condition is reflected back along the guide at 180 to the original direction of propagation.

One known method of providing the reflector is to apply a diffraction grating to an optical fibre. However, preparing such a grating requires a high degree of skill and accuracy. Consequently time consuming manufacture and high rejection rates may be expected resulting in an expensive filter.

Accordingly it is one object of the present invention to provide an effective optical filter which is less costly to manufacture.

According to the present invention there is provided a method of manufacturing an optical filter comprising the steps of lapping or polishing an optical fibre to expose a portion of fibre core, overlaying the exposed core portion with a curable adhesive, setting up a standing wave in the adhesive and rapidly curing the adhesive whereby a corrugated structure is provided.

Preferably an index matching ultra violet curable adhesive is used, curing being effected by use of a high intensity ultra violet light source.

The standing wave is preferably set up using an ultrasonic wave, the frequency of which may be varied during the curing period to provide a chirped structure to the corrugations.

A method of manufacturing an optical filter in accordance with the invention will now be described by way of example only with reference to the accompanying drawings of which:-

Figure 1 shows schematically a section through an optical fibre manufactured in accordance with the invention;

Figures 2A-F show schematically the manufacturing process; and

Figure 3 shows schematically a part of the filter showing a standing wave set up during manufacture.

Before considering the preferred method of manufacturing an optical filter the product of the process will be considered in respect of the technical background. Accordingly, referring to Figure 1, a section through a polished half coupler(PHC) shows the PHC comprising a cladding layer 1 and a fibre core 2. A periodic structure in the form of corrugations 3 has been provided.

The corrugations 3 cause light propagating in the fibre to be scattered in a similar way to light scattered by a diffraction grating and light which strikes the corrugations 3 will be scattered into the cladding 1, into the atmosphere or in either direction along the fibre core 2.

The filter of Figure 1 accordingly acts as a one dimensional Bragg reflector and light of the wavelength which satisfies the Bragg Condition is reflected back along the guide at 180° to the original direction of propagation. The Bragg Condition will be satisfied at different wavelengths in dependance upon the period of the

corrugations 3 thereby providing in the case shown a frequency selective rejection filter in which substantially all the incident power at a specific wavelength is reflected.

Referring now to Figure 2, the method of preparing the filter using a monomode fibre involves mounting the fibre 4 in a channel 6 of a silica block 5. The channel 6 has a slightly curved upper surface and, in practice the upper surface 7 of the block 6 may be curved, the channel 6 being scored therein.

Having mounted the fibre 4, the surface 7 and cladding 1 are lapped and polished to provide a flat surface as shown in Figure 2B in the same manner as used in the preparation of a known PHC. The fibre profile is thus changed to that of D-type fibre as shown in Figure 2F with the cladding polished away to expose a portion of the fibre core 2.

Having so prepared the fibre 4 a thin film 7 of index matched ultra violet curable adhesive, such as an acrylic epoxy adhesive (e.g. "Norland 65") or an acrylic silicone adhesive, is applied to the exposed core 2 of the fibre 4.

Using an accurate ultrasonic source 8 at a frequency calculated as hereinafter described a standing wave is caused to be set up in the, currently liquid, adhesive film 7. Having set up the standing wave, high intensity ultra violet light from a source 9 is used to effect a rapid cure of the adhesive film 7 thereby providing the required Bragg reflector.

It is here noted that during the curing period the frequency of the ultrasonic source 8 may be varied so that the standing wave varies slightly thereby providing a chirped structure which simulates a chirped diffraction grating. This allows production of "bandwidth" filters.

It will be appreciated, however, that using a stable

ultrasonic source, filters having a very narrow bandwidth may be produced enabling accurate rejection of optical signals of a specific wavelength which may find use in demultiplexing wavelength division multiplexed (WDM) signals.

Referring again to Figure 1, it is known that the Bragg condition is satisfied when

$$\lambda = 2n_e D$$

where λ is the wavelength of light in vacuum

n_e is the effective refractive index of the waveguide and

D is the corrugation period.

When reflected light is incident at an angle θ then

$$n_e = n, \sin 2\theta$$

where n, is the refractive index of the guide.

Thus in creating the aforementioned frequency selective rejection filter formation of the standing wave in the adhesive overlay 7 requires excitation of the liquid film at a predetermined frequency to create a corrugation having a specific period D. The required excitation frequency (F) is given by

$$F = \frac{c}{D}$$

where c is the speed of propagation of the wave in an overlay.

Since for fluid flow is a free surface film the surface pressure along the surface cannot vary from point to point then a disturbance of the fluid 7 will propagate

as a surface wave not as a pressure wave.

Referring then to Figure 3 and providing

C = wave propagation velocity and

h = mean adhesive film thickness with

Q = the flow through a section of unit width measured perpendicular to the direction of propation, in considering a vertical section through the film at 'A' where the excited depth equals the mean depth h

then $C = \frac{Q}{h}$

Now as at any vertical section the total energy of the film is constant, gain in kinetic energy in the peak of the wave must equal the loss in potential energy in the trough. Therefore at A the total energy of the liquid (E) is given by

$$E = h + \frac{c^2}{2g}$$

and since $C = \frac{Q}{h}$,

$$E = h + \frac{Q^2}{2gh^2}$$

As this applies at any section $\frac{dE}{dh} = 0$

therefore differentiating

$$\frac{dE}{dh} - 1 - \frac{2Q^2}{2gh^3} = 0$$

or since $\frac{Q}{h} = C$

$$1 - \frac{C^2}{gh} = 0$$

Thus $C = gh$

Using the above equations the required frequency of the source 8 for any required filter may be calculated.

Thus in a typical single mode (monomode) optical fibre the angle ć given by the critical angle for the core/cladding interface is given by

$$\hat{a} = \sin^{-1} \frac{n_2}{n1} \text{ (typically)} = \frac{1.456}{1.46}$$

Thus $\hat{a} = 85.76$

Accordingly from $n_e = n1 \sin 2\hat{a}$ (above)

$$n_e = 0.2154$$

Now since $D = \frac{¶}{2ne}$

for wavelengths of, say, 1 550 nm and 1300 nm D is respectively 3.6?m and 3.01?m. Accordingly with an adhesive film thickness of 50?m

$$c = gh = 9.81 \times 50E^{-6}$$

$$= 0.0221 \text{ m/s} = 22147?/s$$

Now since $f = \frac{c}{D}$

$f = 6.152\ kH_z$ for a filter having a rejection wavelengtn

of 1550 um

and f = 7.358 kH_z for a filter having a rejection wavelength of 1300 um.

It will be realised that the above examples are exemplary only to demonstrate calculations in respect of a particular fibre and particular frequencies.

CLAIMS

1. A method of manufacturing an optical filter comprising tne steps of lapping or polishing an optical fibre to expose a portion of fibre core, overlaying the exposed core portion with a curable adhesive, setting up a standing wave in the adhesive and rapidly curing the adhesive whereby a corrugated structure is provided.

2. A method according to Claim 1 wherein adhesive curable with ultra-violet light is overlayed on the exposed portion, the adhesive being cured by use of a high intensity ultra violet light source.

3. A method according to Claim 1 or Claim 2 wherein the standing wave is set up using an ultrasonic wave.

4.A method according to Claim 3 wherein the frequency of tne ultrasonic wave is varied during the curing period whereby a chirped structure is provided.

5. An optical filter manufactured by the method of any one of Claims 1 to 4.

Fig.1.

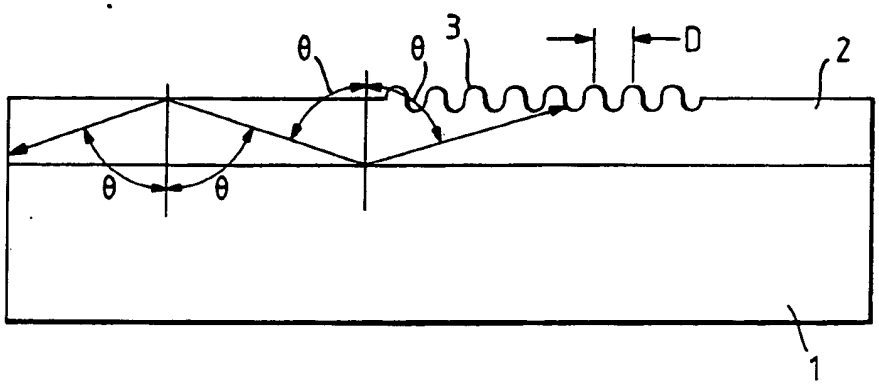


Fig.3.

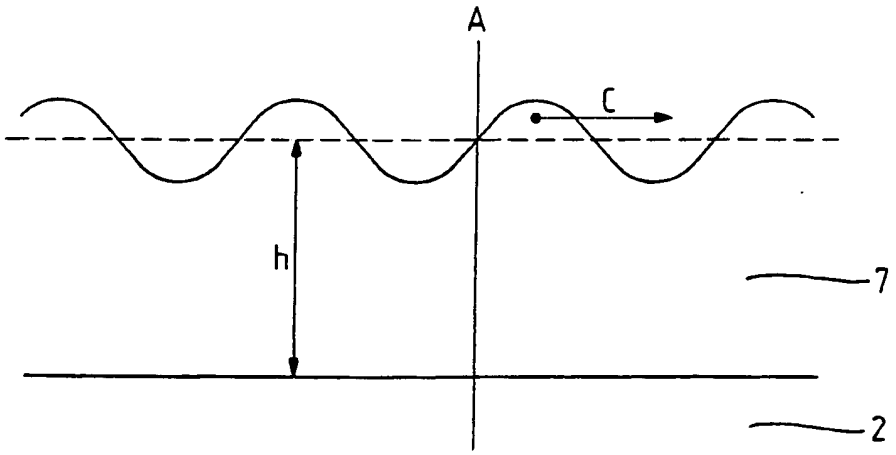


Fig.2A.

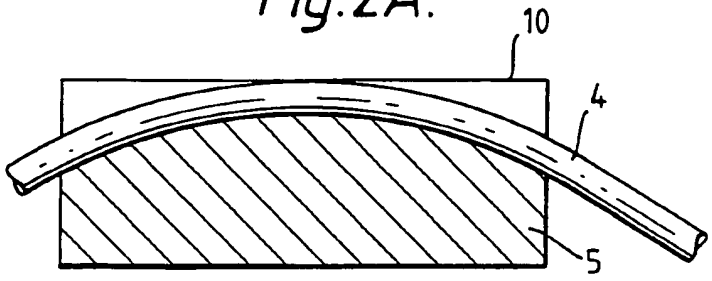


Fig.2B.

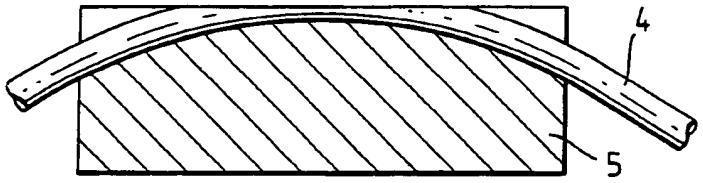


Fig.2C.

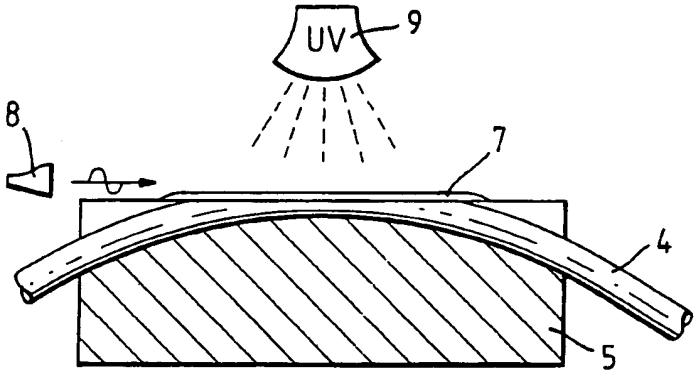


Fig.2D.

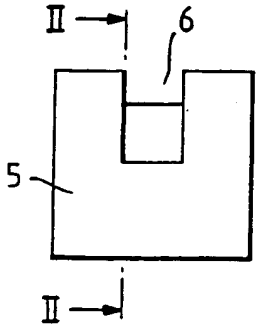


Fig.2E.

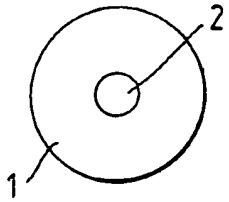
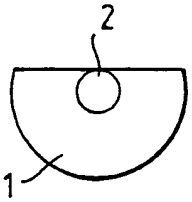


Fig.2F.



INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 88/00741

I. CLASSIFICATION F SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4]: G 02 B 6/34

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[4]	G 02 B; H 01 S; G 02 F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	Radio Engeneering and Electronic Physics, volume 28, no. 5, May 1983, Scripta Publ., (Silverspring, US), A.F. Bessonov et al.: "Waveguide-optical readout of signals in devices employing acoustic surface waves", page 149-156 see figure 1; page 149, lines 19-26; page 150, lines 1-5; page 154, lines 28-33 --	1,3
A	GB, A, 2096344 (THE WARCONI CO. LTD) 13 October 1982 see figures 1,2; abstract; page 1, lines 91-100 --	1,3
A	EP, A, 0005187 (SIEMENS AG) 14 November 1979 see figure 2; abstract; page 9, lines 23-30 --	3
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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
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EUROPEAN PATENT OFFICE	P.C.G. VAN DER PUTTEN

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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FR M THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	EP, A, 0216565 (PLESSEY OVERSEAS LTD) 1 April 1987 see figure 2; abstract; column 3, lines 62-65; column 4, lines 1-5, 40-46	1,2

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 8800741

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 13/12/88
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A- 2096344	13-10-82	None	
EP-A- 0005187	14-11-79	DE-A- 2820245	15-11-79
		US-A- 4213810	22-07-80
		JP-A- 54147849	19-11-79
EP-A- 0216565	01-04-87	AU-A- 6247686	12-03-87
		JP-A- 62111212	22-05-87